CLAIMS

What is claimed is:

1. A method for detecting substances, the method comprising:

performing multi-view, multi-energy radiography by irradiating an object with a plurality of discrete, nuclear-reaction-based high-energy gamma-rays at a plurality of different orientations, and detecting and mapping radiation passing through the object with at least one array of detectors; and

indicating the presence of a high-**Z** substance by detecting a difference in a transmission attenuation characteristic of the high-**Z** substance as opposed to low-**Z** and medium-**Z** substances.

2. The method according to claim 1, further comprising determining and localizing regions within said object containing the high-Z substance with the multi-view, multi-energy radiography.

3. The method according to claim 1 or claim 2, further comprising determining and localizing regions within said object containing high-density substances with the multi-view, multi-energy radiography.

4. The method according to any of claims 1-3, wherein the high-Z substance comprises a special nuclear material (SNM).

5. A system for detecting substances, the system comprising:

a dual-energy radiography (DER) system comprising a gamma-ray radiation source, including an ion-beam accelerator and a target to which said accelerator sends a beam thereby producing gamma rays, and a plurality of gamma ray detectors or detector arrays positioned to detect gamma ray beams that pass from the gamma-ray radiation source through an object to be inspected, wherein the DER system is adapted to indicate a presence of a high-**Z** substance, by detecting a difference in a transmission attenuation characteristic of the high-**Z** substance as opposed to low-**Z** and medium-**Z** substances.

6. The system according to claim 5, wherein said DER system is adapted to make two measurements of transmission attenuation characteristics, one measurement performed at the global absorption minimum for all atomic numbers **Z** (at approximately **4 MeV** photon energy) and another at a higher photon energy.

7. The system according to any of claims 5-6, wherein said DER system is adapted to distinguish a presence of a special nuclear material (SNM) as opposed to a benign, high-Z substance, based on a measurement of the density of the object to be inspected, as derived from said plurality of gamma ray detectors or detector arrays.

8. The system according to any of claims 5-7, wherein said gamma-ray radiation source comprises a discrete-energy nuclear-reaction-induced source.

9. The system according to any of claims 5-8, wherein said gamma-ray radiation source comprises at least one of the target and beam-projectile combinations $^{11}B+p$, $^{11}B+d$, $^{13}C+^{3}He$ and $^{10}B+^{3}He$, giving rise to nuclear reactions at beam energies $\mathbf{E_{beam}} <\sim \mathbf{6\ MeV}$.

10. The system according to any of claims 5-9, wherein said gamma-ray radiation source also emits neutrons adapted to enhance SNM detection capability and reduce false-positives.

11. The system according to any of claims 5-10, wherein said target is surrounded by at least one of neutron-moderators and absorbers.

12. The system according to any of claims 5-11, wherein the detectors are at least partially enveloped in a thermal-neutron-absorbing material.

13. The system according to any of claims 5-12, wherein said detectors comprise organic scintillators.

14. The system according to any of claims 5-13, wherein said detectors comprise at least one of scintillators with pulse-shape-discrimination properties, an inorganic scintillator spectrometer, and a solid-state radiation spectrometer.

15. The system according to any of claims 5-13, wherein said detectors comprise time-of-flight capabilities for suppressing neutron-related spectral background and activation gamma-rays.

16. The system according to any of claims 5-15, wherein said beam accelerator system emits ion-beams of d^+ at around 3.5 MeV energy, or H_2^+ at twice the energy of the 1.75 MeV $^{13}C(p,\gamma)$ capture resonance, and wherein the DER system is adapted to indicate a presence of the high-**Z** substance and nitrogenous explosives as a function of the transmission attenuation characteristics of the high-**Z** substance and the nitrogenous explosives.

17. The system according to claim 16, wherein said beam accelerator system emits mixed ion-beams of d^+ and H_2^+ at twice the energy of the 1.75 MeV $^{13}C(p,\gamma)$ capture resonance, and wherein the DER system is adapted to indicate the presence of the high-**Z** substance and the nitrogenous explosives in the same scan.

18. The system according to claim 16-17, wherein the DER system is adapted to indicate the presence of the high-**Z** substance and the nitrogenous explosives in the same scan by bombarding a thin $\mathbf{^{13}C}$ layer deposited on the surface of a thick $\mathbf{^{11}B}$ target, with a mixed beam comprising $\mathbf{H_2^+}$ and deuterons, both at twice the energy of the 1.75 MeV $^{13}C(p,\gamma)$ capture resonance.

19. The system according to any of claims 5-18, wherein the high-Z substance comprises a special nuclear material (SNM), and the DER system is adapted to distinguish the SNM from at least one of rare-earth elements, transition metals and other stable heavy elements.

20. The system according to any of claims 5-19, further comprising a non-DER system for detecting substances in combination with said DER system.